W. Guggenbühl, M. J. O. Strutt and W. Wunderlin: **Halbleiterbauelemente, Vol. 1, Semiconductors and Semiconductor Diodes.** Birkhäuser, Basel-Stuttgart, 1962. pp. 255, sFr. 38.50.

The authors are well known for their many important contributions to the semiconductor device field, and especially in the field of noise.

Since the approach of the authors is a utilitarian one, the first part of the book follows a very clear pattern of an introduction into basic properties of semiconductor crystals, carrier transport phenomena and surface effects. The second part of the book deals with semiconductor diodes. Most aspects are considered including tunnel effect and thermal problems. The book ends with a treatment of switching properties and reliability considerations.

The material is arranged such that five general topics are discussed and the reader gradually is introduced into the most important parts in this area starting from materials properties and proceeding to transport problems, to the p–n junction, and finally to diode problems.

An extensive literature survey (311 citations) and a name-and topic-list concludes the book which also contains a complete list of all symbols used.

In the text the starting question, "What is a Semiconductor?", is qualitatively answered by a resistivity range scale. The next step is a definition of the mobility of carriers as the proportionality factor in the field versus mean velocity expression.

The intrinsic conductivity of the homopolar lattice material like germanium or silicon is introduced on a comparison basis ($n_{\text{atom}}/n_i \cong 1/10^9$).

The extreme requirements as to purity of the materials are explained. The doping problem is outlined and useful graphs of resistivity versus impurity density for n- and p-type Ge and Si are added. In Chapter 1.3 the band picture is introduced and the transition insulator-metal is explained by a gradual band overlap. After description of the donor and acceptor impurity the Fermi-distribution function and the effective state density are introduced.

The degenerate and nondegenerate electron gas in crystals is discussed in a rather descriptive but very readable fashion. From here the reader is led to carrier transport problems starting with the mobility concept. In this context the hot carrier concept is introduced and a useful graph for the mobility as a function of impurity concentration is given.

After an introduction into the nonequilibrium concentration of carriers and recombination processes, carrier diffusion is described and the fundamental equations for expression of the current densities in a semiconductor (j_n, j_p) are derived. The surface is dealt with in a rather short chapter. An explanation of the surface states due to crystal boundaries (free surfaces, grains) is given by the Bardeen–Brattain model. A short chapter on the production methods for semiconductor monocrystals (Czochralski and floating zone crystal growth) concludes the first part of the book.

Chapter 2 dealing with the semiconductor-diode starts with the idealized cases of small current density and no recombination. The carrier density versus field expressions for a depletion layer are derived, the carrier concentrations in the different regions of the junction are represented, and the diffusion-model is finally used to derive the WAGNER–SCHOTTKY diode characteristics.

As the book emphasizes the engineering point of view the reader finds here already a representative scheme of the diode and a clear definition of the diffusion-capacity in distinction to the barrier layer capacity.

The complete scheme of a p–n junction at small current densities and corresponding R–C network representations are outlined. The next subchapter (2.2) is a thorough discussion of deviations from the simple diffusion model of a p–n junction. It is mentioned that especially the silicon case shows deviations due to recombination and microplasma breakdown effects.

The case of high current densities is outlined in reference to the work of HERLET on abrupt symmetrical p–n junctions and an original approach of GUGGENBÜHL for the nonsymmetrical diode is derived. The result is of practical value since most diodes are nonsymmetric. The calculated results for the potential distribution and the voltage distribution between barrier layer and spreading resistance with increasing current density are in good agreement with measured values.

In the case of very high (degenerate) doping ($n \gg n_{\mathrm{eff}}$) the diode behavior is governed by tunneling processes. This case is dealt with in the next chapter. The authors first derive carefully the quantum mechanical problem of barrier penetration with the three solutions of Schrödinger's equation and the corresponding amplitude functions. This solution is then applied to real degenerate junctions in the way first described by ESAKI, such that the tunnel characteristic is a superposition of currents resulting from transitions from the valence to the conduction band and vice versa.

Now the p–n junction in the reverse bias case is considered. The different phenomena are discussed, as Zener- and avalanche-breakdown. The favorably low temperature dependence of this portion of the characteristics and its importance for the circuit designer are emphasized. Microplasma breakdown effects and attendant increase in noise power and recombination light are described as typical for silicon and dominated by the midband dislocation levels. Thermal breakdown effects (Ge) are discussed and the important p–i–n and p–s–n diodes are mentioned.

With this the authors enter into the more practical part of their book and a description of ohmic contacts, contact materials and properties of special diode types follows. Selenium and cuprous oxide diodes are discussed. A short chapter on photodiodes and solar batteries concludes this part.

Finally the important question of the temperature behavior of the diode characteristics is brought up with measured curves of the reverse current dependence on temperature for germanium and silicon diodes. The rest of the book deals with the more engineering-type questions of thermal stability, cooling problems, optimal design, circuit design and behavior in circuits, as well as device yield and aging.

As this short description tells, the material presented in this book is of great concern for the electronics engineer and can be highly recommended to all those who desire a thorough but condensed description of this major field of device physics and technology. A second volume is announced dealing with the transistor.

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